In Figure 44 the train was running, the 1200 kVAR capacitor bank on Feeder 14101 was in, all other capacitor banks were out, and the 1200 kVAR capacitor bank was switched out at the time indicated. A train impulse noise signature was noted immediately upon capacitor switching over the 4 to 6 kHz frequencies. The data in the two bottom views of Figure 44 were identical except for the display threshold level settings. The upper amplitude vs. frequency view was taken with an azimuth setting of about 30° left of the center to permit the separation of train-related impulses from the background noise. The views of Figure 44 were taken with instrumentation connected to the McGraw-Edison 1000 to 1 voltage divider connected to Phase A of the distribution line.

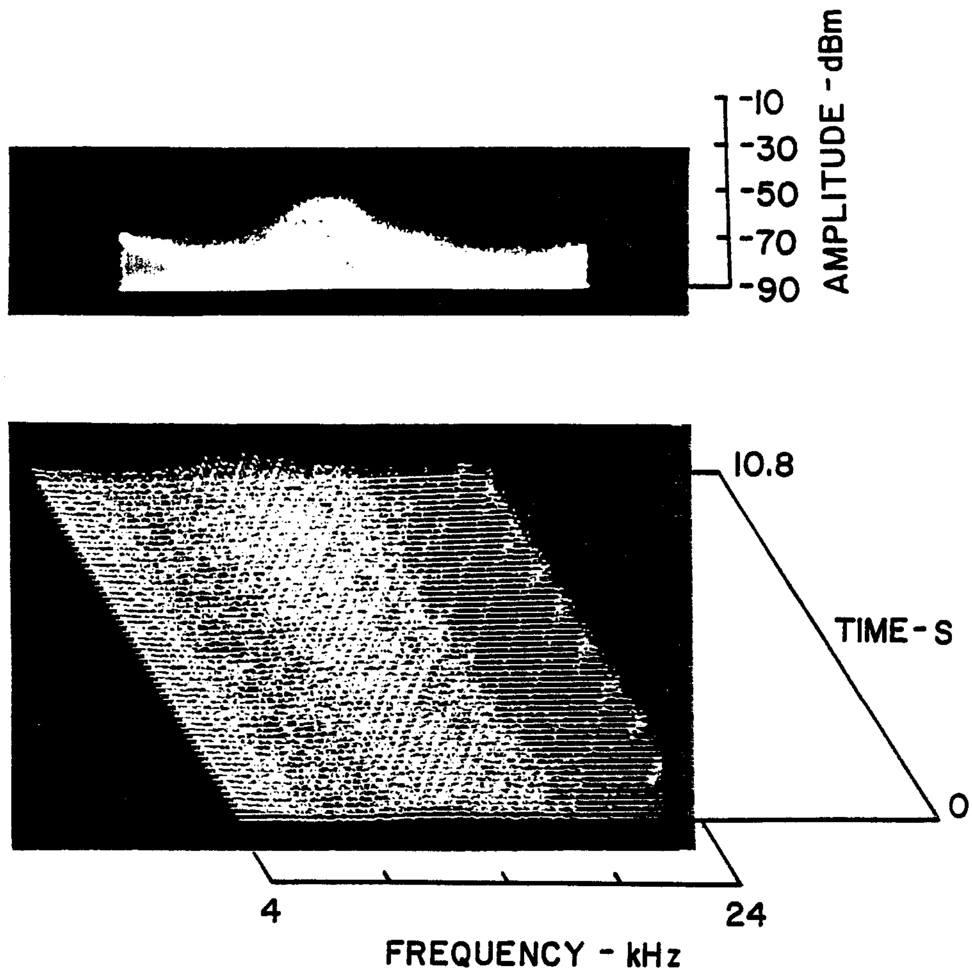


Figure 34   Landover Road Site, 10/26/78, 1147

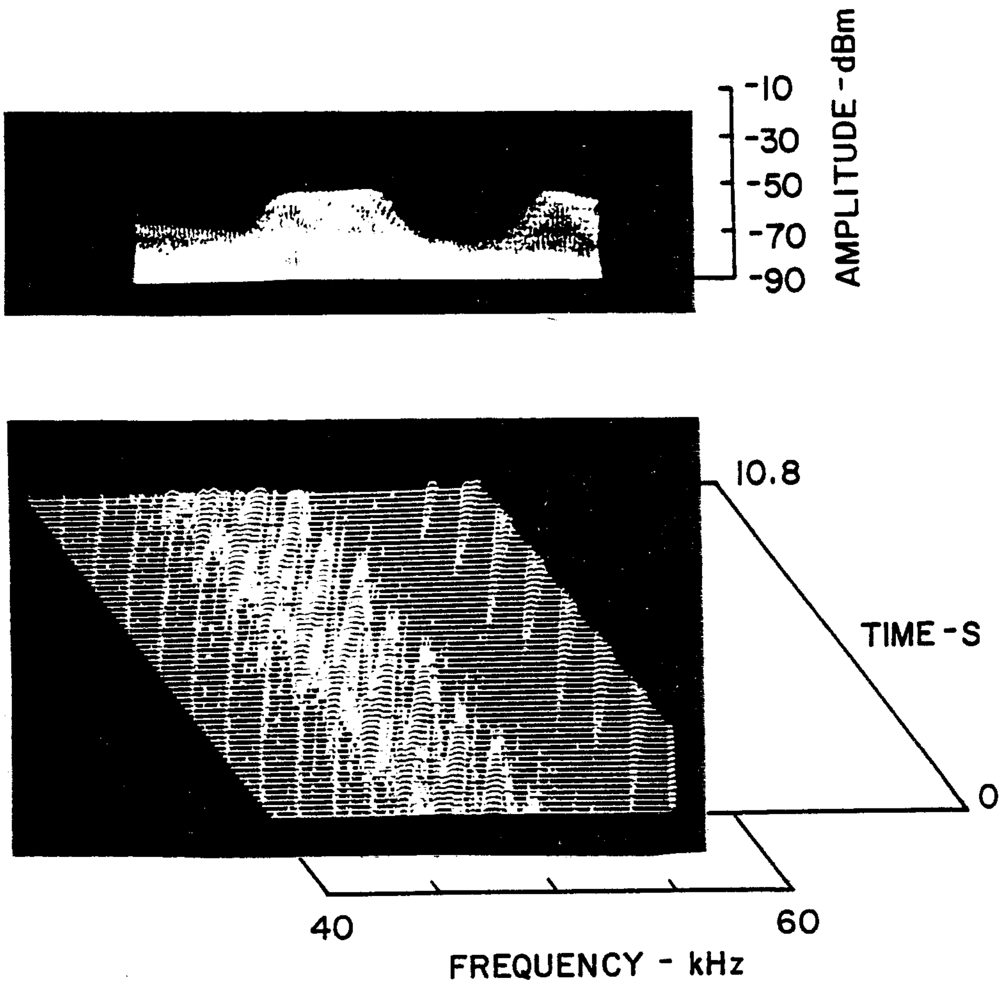


Figure 35   Landover Road Site, 10/26/78, 1153

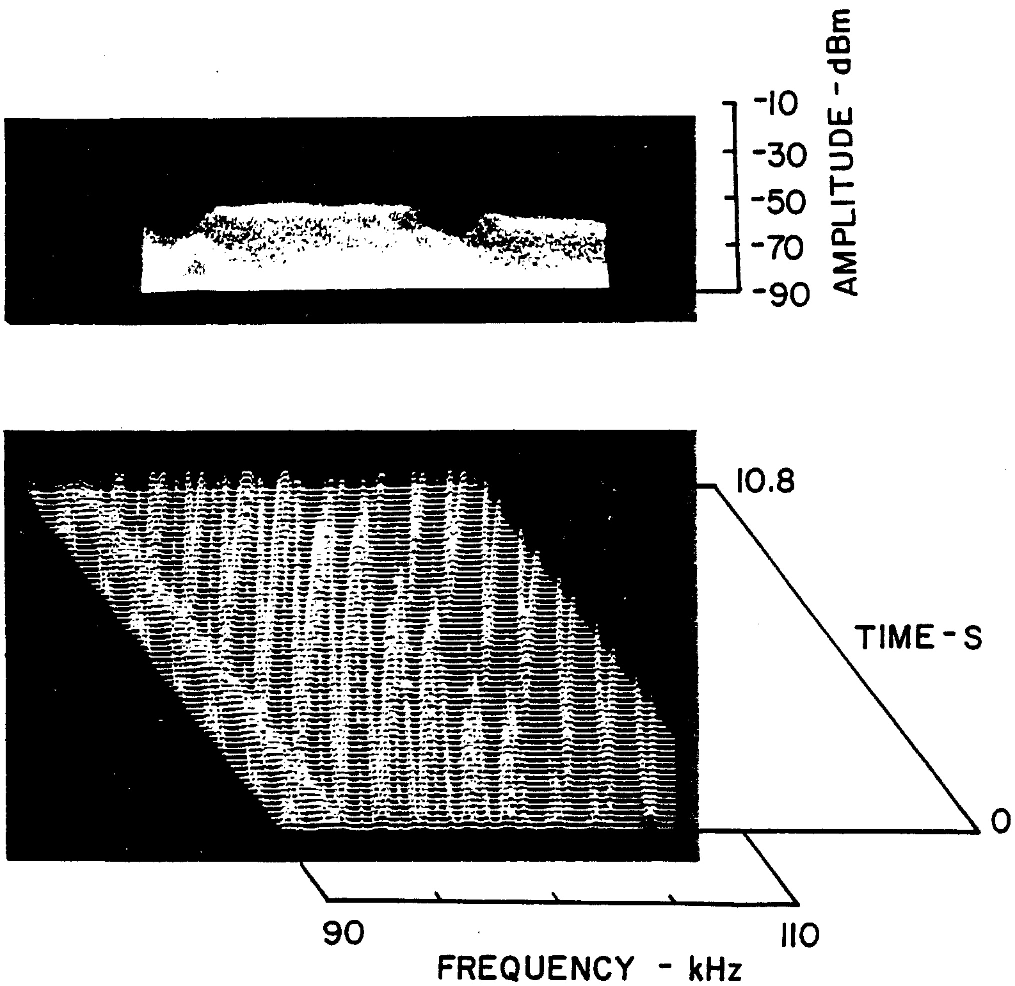


Figure 36 Landover Road Site, 10/26/78, 1159

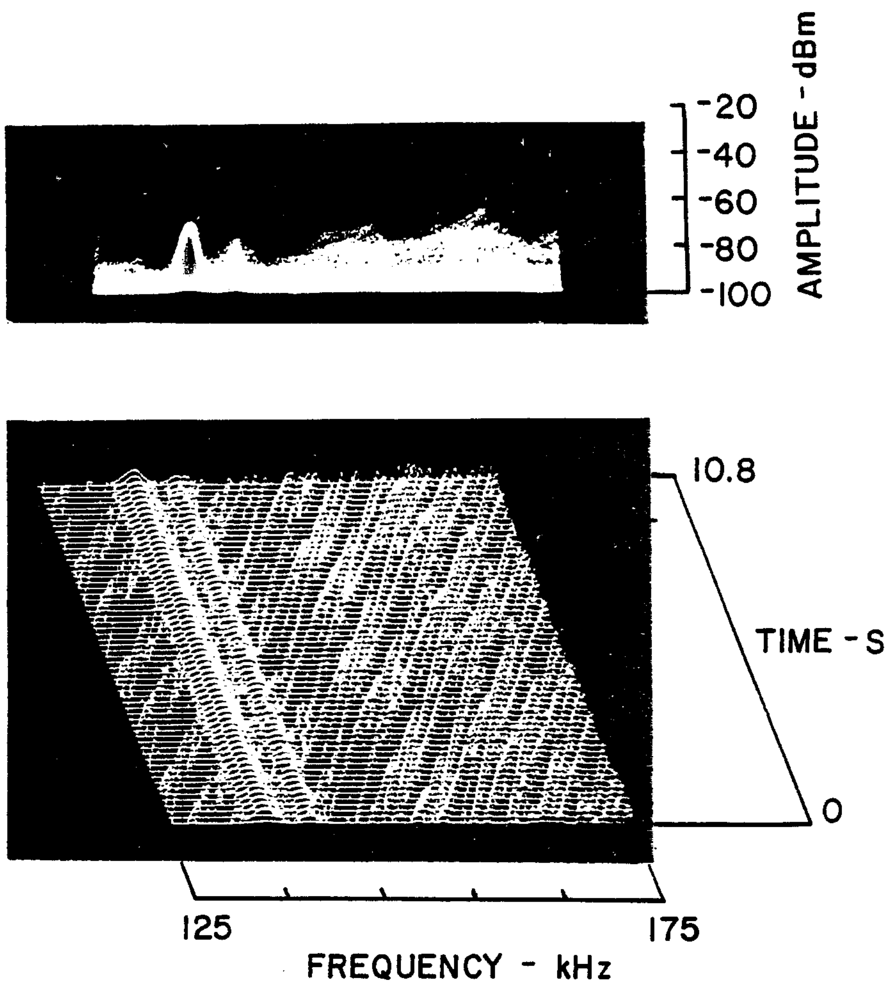


Figure 37 Landover Road Site, 10/26/78, 1216

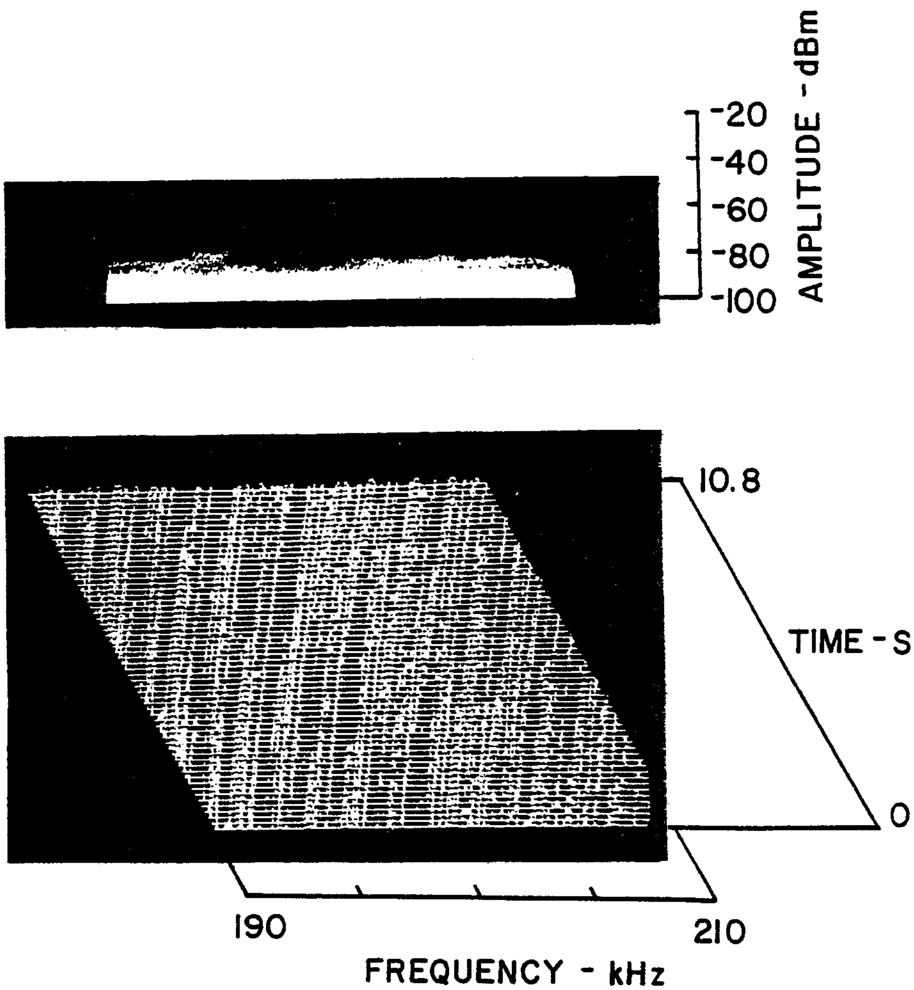


Figure 38 Landover Road Site, 10/26/78, 1227

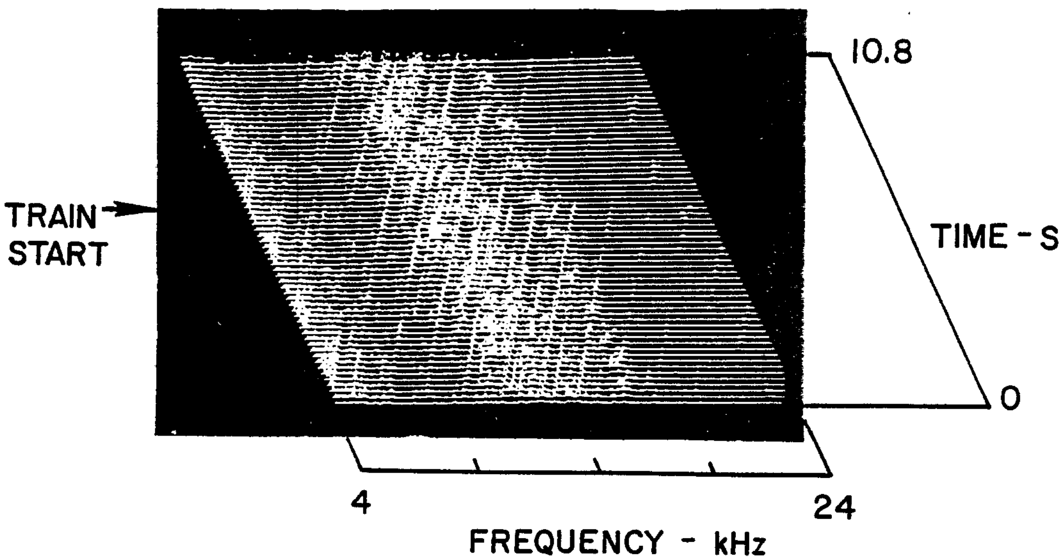


Figure 39 Landover Road Site, 10/25/78, 1231

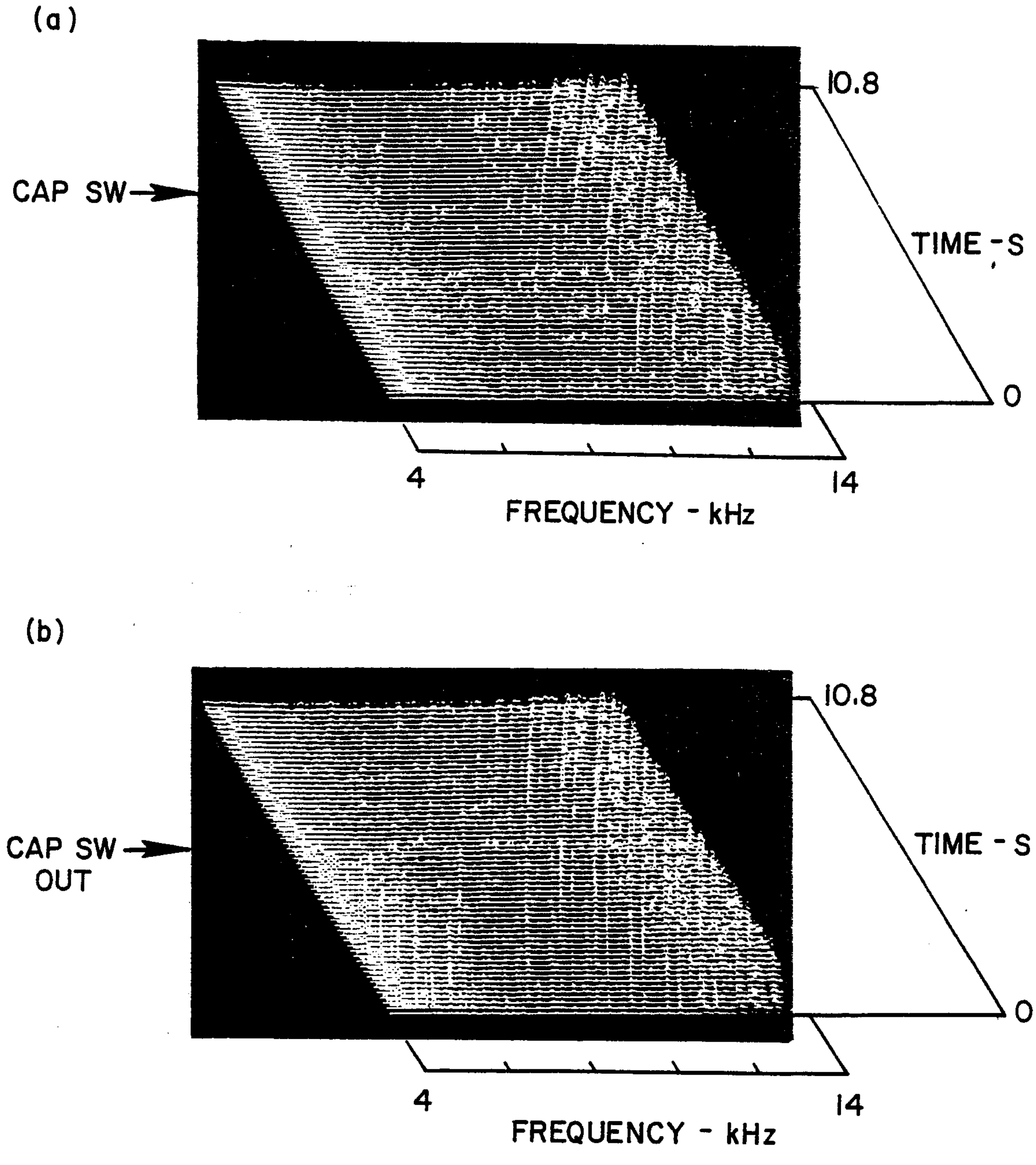


Figure 40 Landover Road Site, 10/25/78, 1305

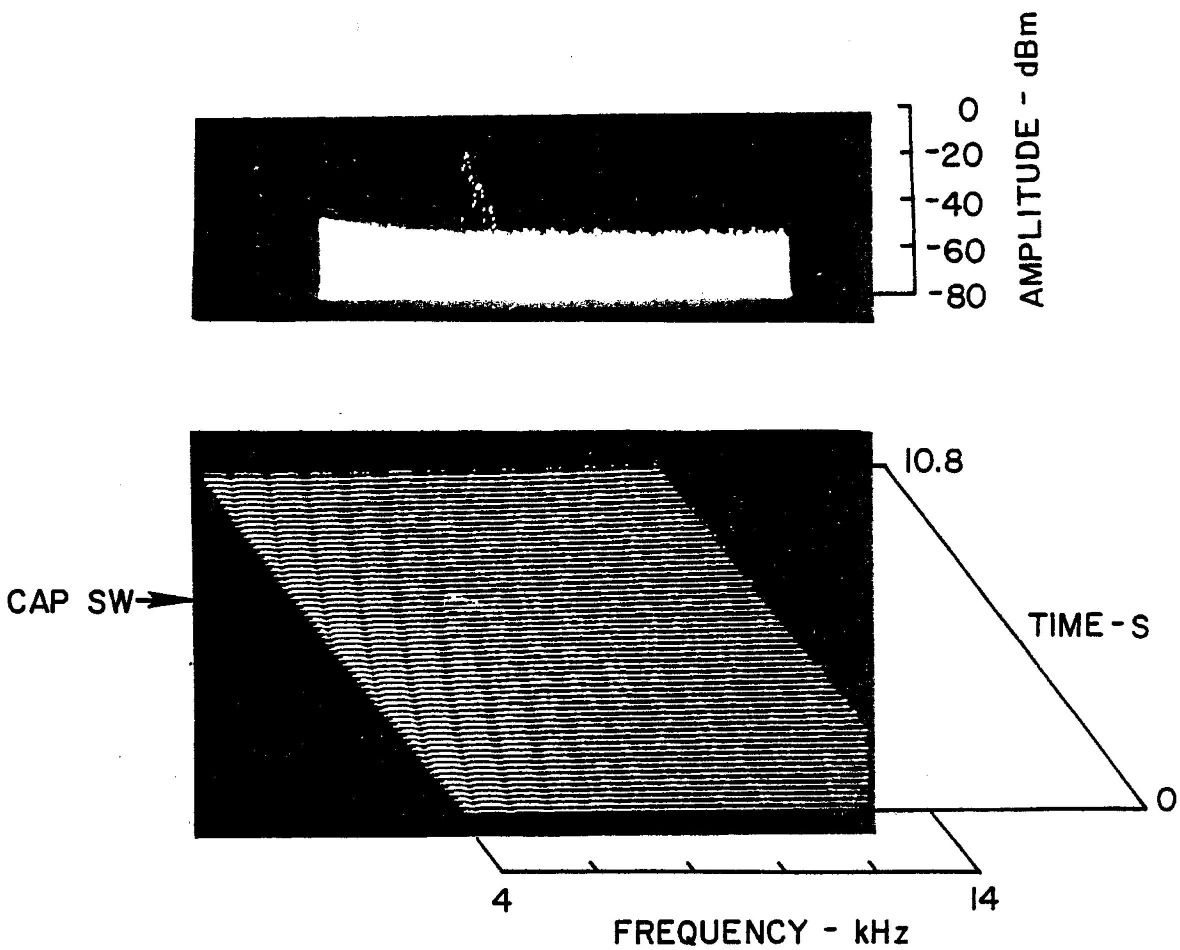
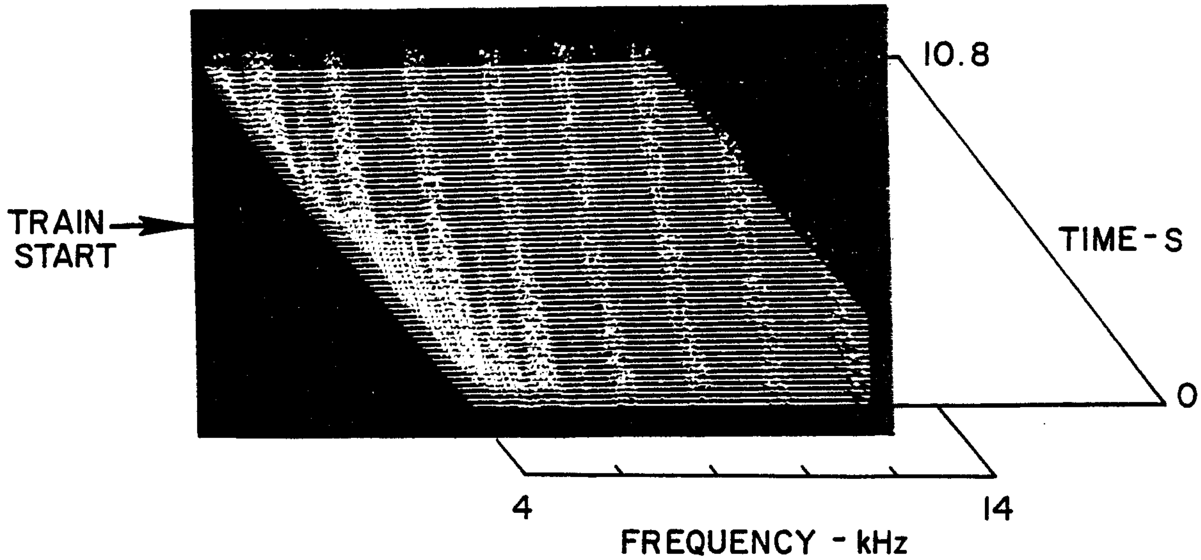


Figure 41   Landover Road Site, 10/26/78, 1330



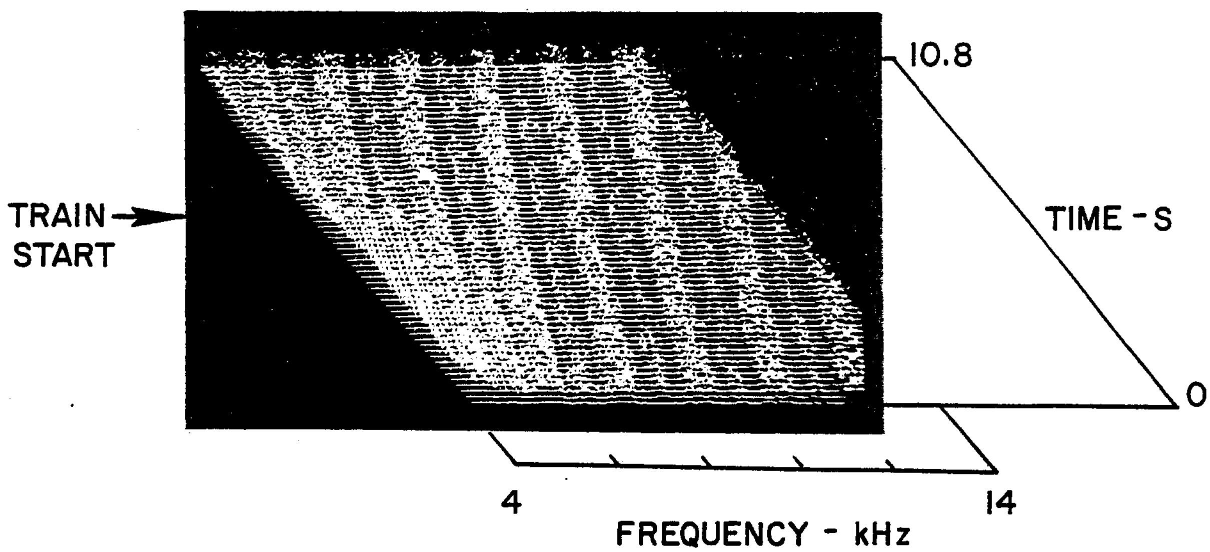


Figure 42 Landover Road Site, 10/26/78, 1355

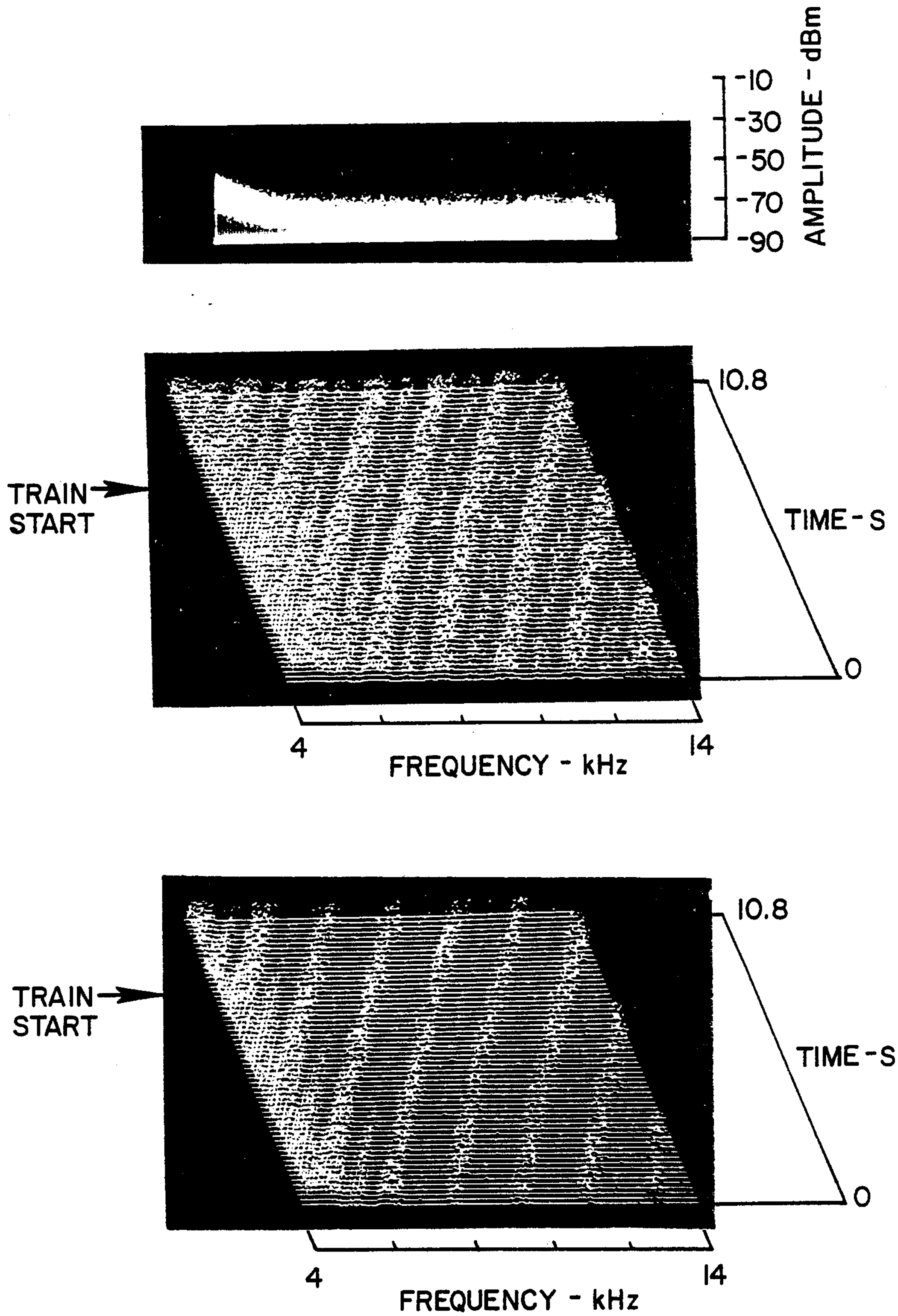


Figure 43 Landover Road Site, 10/26/78, 1403

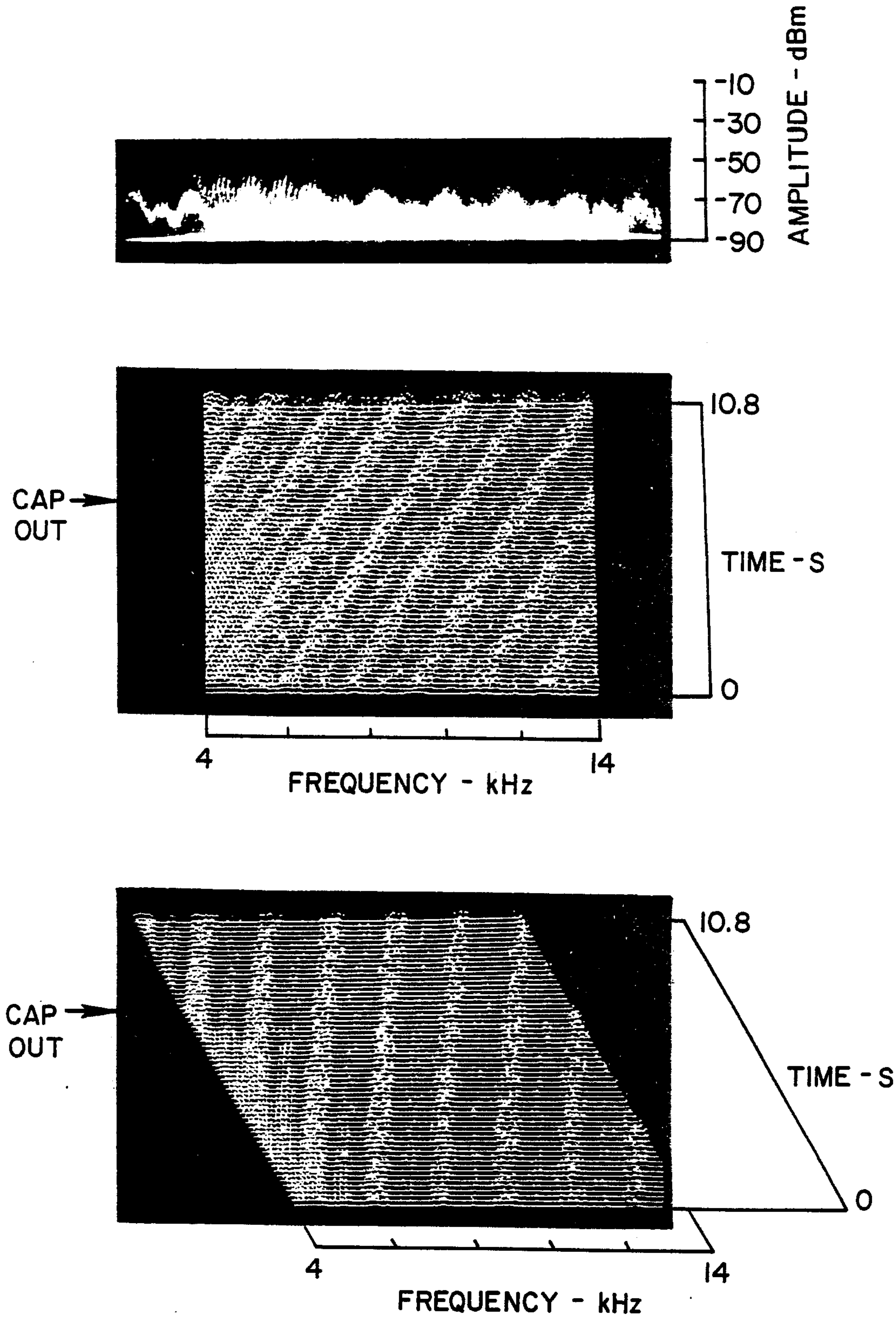


Figure 44   Landover Road Site, 10/26/78, 1415

3.8 TRACK SITE

3.8.1 Measurement Conditions

Additional sites were selected for supplementary measurements whenever time permitted. A site adjacent to the WMATA tracks was selected to examine impulsive noise levels along the d.c. power rail supplying traction power to the trains. The van was located 60' from the tracks and about 1500' south of the Landover, Maryland terminal. The loopstick antenna sensor was located on top of the van about 7' above the ground.

Measurements were made at the WMATA track site on 11/25/78 from about 1515 to 1630 hours local time. Trains were operated by WMATA peronnel on the section of tracks near the van. For most runs the train was started about 1/2 mile south of the site and continued on into the Landover terminal. A reverse direction run was then monitored.

Measurement system parameters for the various 3-axis views taken at the WMATA track site are summarized in Table 11.

Table 11

MEASUREMENT SYSTEM PARAMETERS, TRACK SITE

3-AXIS FIGURE NUMBER	DATE	LOCAL TIME	ANTENNA TYPE	LOOP FREQ. kHz	CENTER FREQUENCY kHz	FREQ. WIDTH kHz	IF BAND-WIDTH kHz	SCAN TIME ms	IF REF dB	RF REF dB
45	10/25/78	1539	Loop	10-40 T10	35	50	1	100	-10	0
46	10/25/78	1548	Loop	40-150 T75	100	100	1	100	-10	0
47	10/25/78	1551	Loop	40-150 T100	100	100	1	100	-10	0

3.8.2 Noise Measurements

Figure 45 shows impulsive noise emanating from the power rail and train tracks as the train started. Train start was at 8 seconds down the time scale. Impulsive noise with a period of 2.5 ms (400 impulses/second) was noted immediately over the 10 to 35 kHz portion of the view. Above 35 kHz the primary impulse period was 10 ms with a smaller amplitude component midway between each of the 10 ms impulses. The upper view shows the two amplitude levels from 35 kHz upward in frequency. Two low level continuous wave signals also appeared in the view at 22 kHz and at 59 kHz.

Figure 45 also shows weak background impulsive noise with a period of ≈18 ms (≈ 55.5 impulses/second). This noise can be seen from 10.8 to 8 seconds on the time scale over the 10 to 45 kHz frequency range. This noise also can be found under the train noise in the 8 to 0 second portion of the view. The source of this background noise was not determined.

A second view of the impulsive noise from the train is shown in Figure 46. The pulses with a period of 2.5 ms (400 impulses/second) were noted over the 50 to 100 kHz portion of the view. Also, continuous wave signals were found at 50, 60, 110 to 120, 138, and 140 kHz. Several of these continuous wave signals were identified as power carrier communications signals emanating from a large utility transmission line about 200' from the measurement site (across the WMATA tracks and running parallel with the tracks).

A second view of impulsive noise over the 50 to 150 kHz band of frequencies is shown in Figure 47. The loopstick was retuned for this view to emphasize the power carrier communications signals and to obtain a signal-to-impulse noise amplitude measurement. The strongest power carrier signal was 25 dB above noise at the measurement site.

The 400 Hz impulsive noise in the three sets of 3-axis views shown in Figures 45 through 47 was generated by a d.c. switching device onboard the train employed for control of traction power. Impulse currents at the switching time were at least as high as the traction current drawn from the d.c. supply rail.

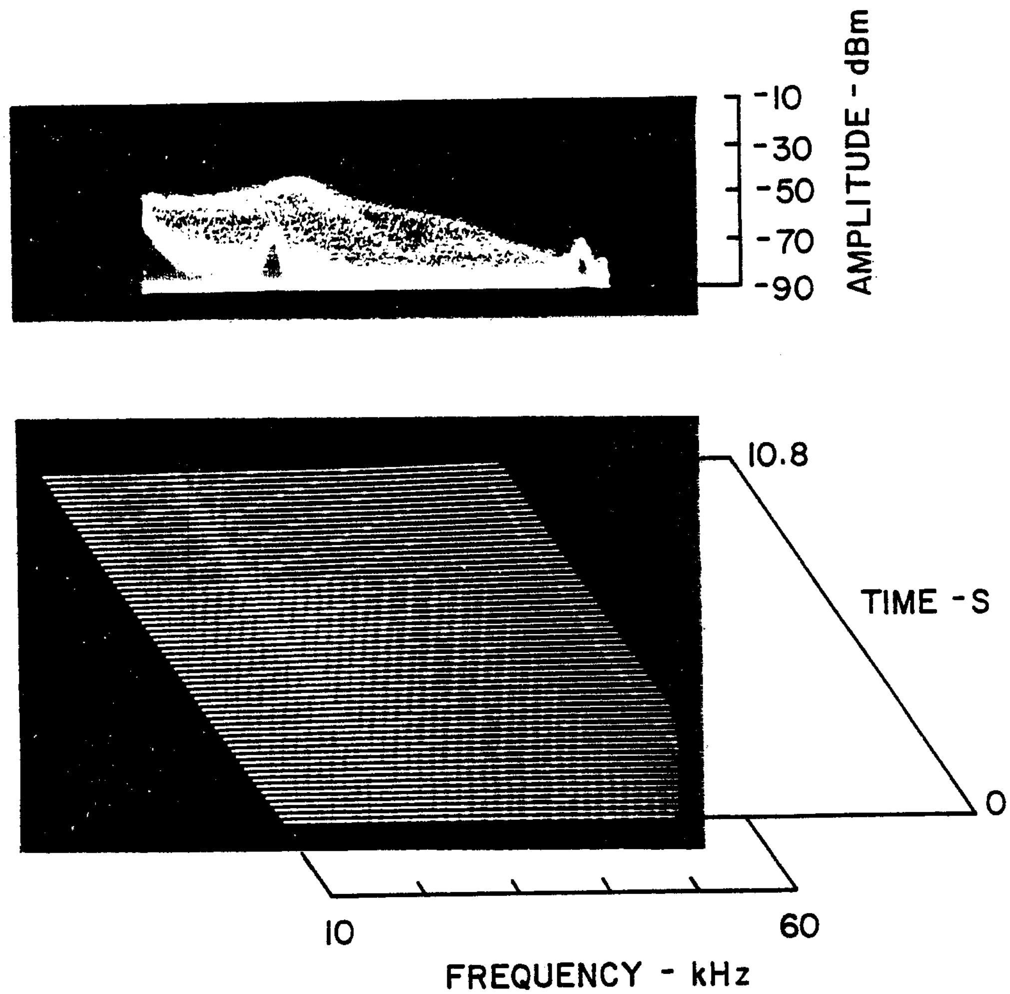


Figure 45 Track Site, 10/25/78, 1539

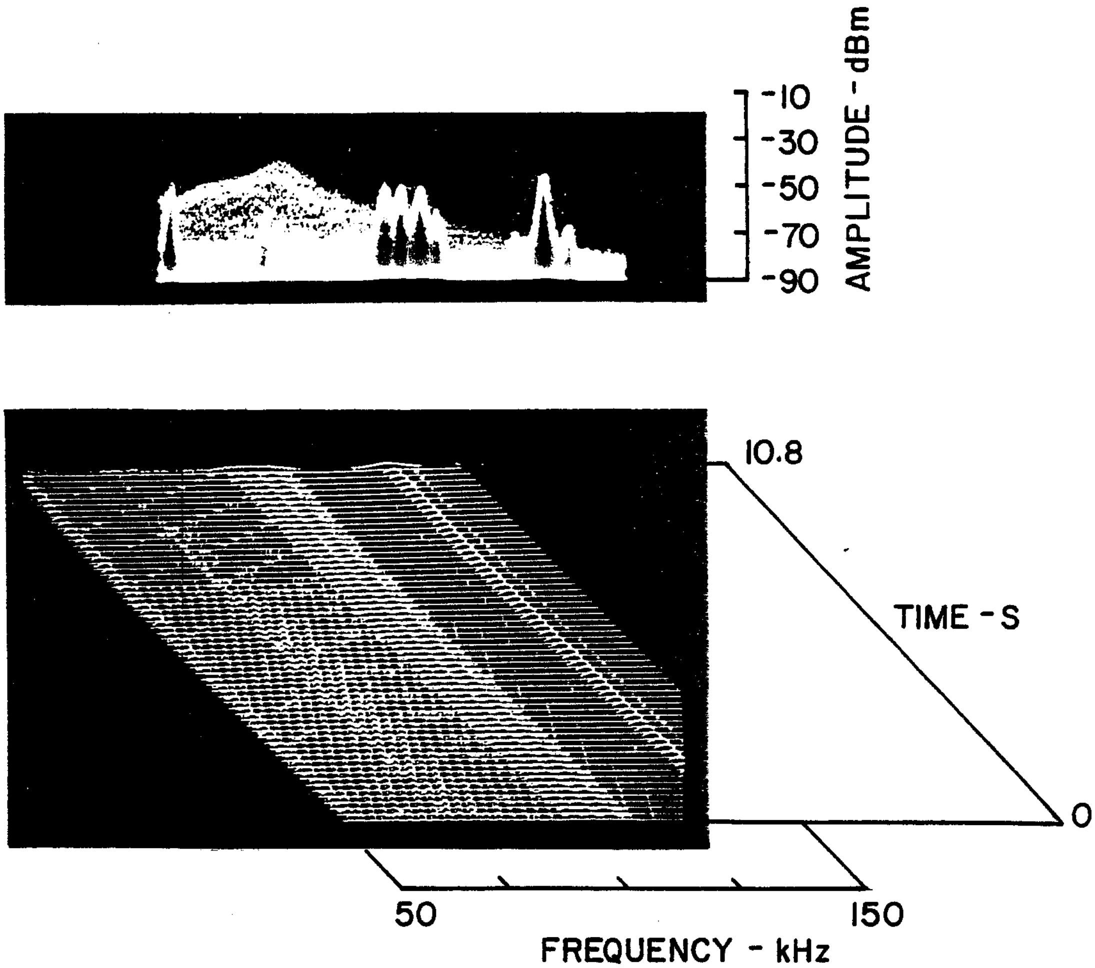


Figure 46   Track Site, 10/25/78, 1548

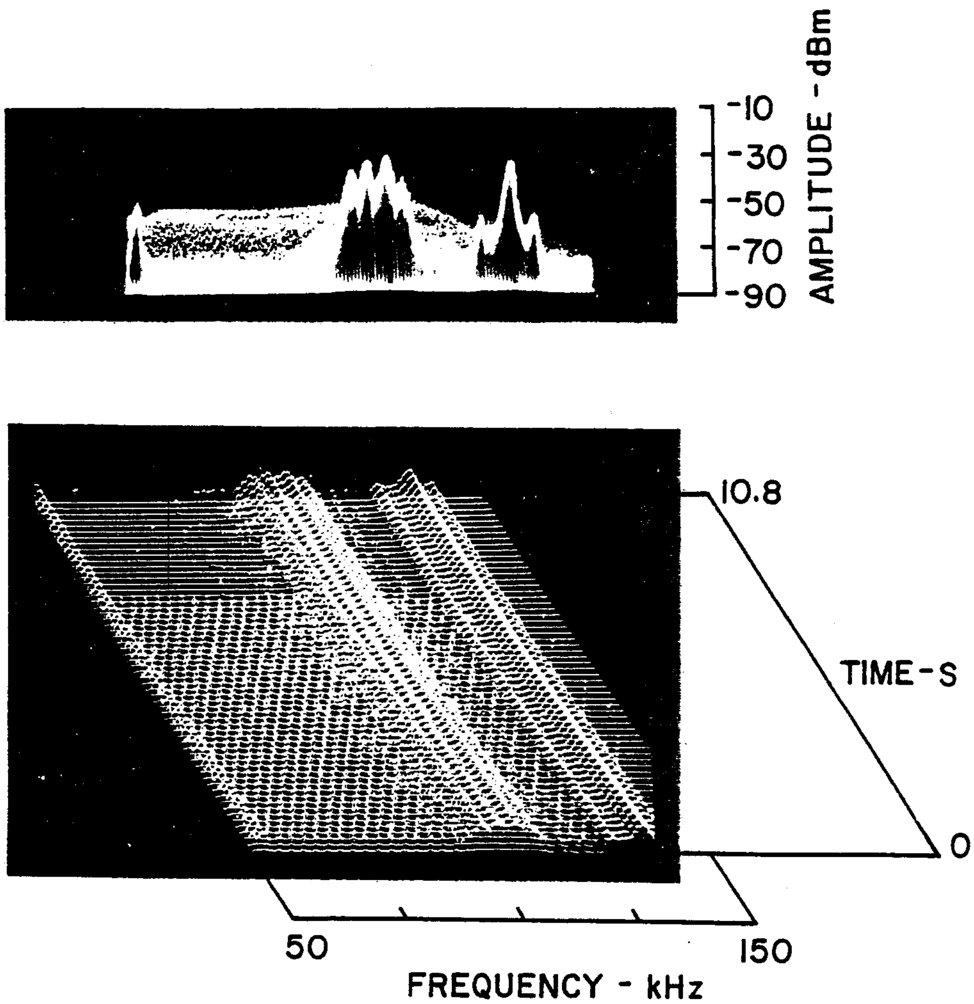


Figure 47 Track Site, 10/25/78, 1551

3.9 RECTIFIER BUILDING SITE

3.9.1 Measurement Conditions

Additional supplementary noise measurements were made at the WMATA rectifier building located near the PEPCO Tuxedo substation. The rectifier building was constructed of concrete blocks which appeared to be transparent to radio signals. The roof was made of sheet steel where the sheets appeared to be solidly bonded together with bolts. The metal roof was grounded with lightning protection cables. The rectifier building was supplied with electrical power by an underground feeder from the nearby Tuxedo substation.

Noise emanating from the physically large components of the rectifiers, interval building wiring, connections between the rectifiers and associated a.c. switch gear and transformers, and building grounding was examined. The measurement van was located about 75' from the building with the loopstick antenna about 50' from the building. Measurements were made on 10/24/78 from about 1520 to 1730 hours local time.

Measurement system parameters for the various 3-axis views taken at the WMATA rectifier building are summarized in Table 12.

Table 12

MEASUREMENT SYSTEM PARAMETERS, RECTIFIER BUILDING

3-AXIS FIGURE NUMBER	DATE	LOCAL TIME	ANTENNA TYPE	LOOP FREQ. kHz	CENTER FREQUENCY kHz	FREQ. WIDTH kHz	IF BAND-WIDTH kHz	SCAN TIME ms	IF REF dB	RF REF dB
48	10/24/78	1528	Loop	10-40 T10	8	10	1	200	-10	0
49(a)	10/24/78	1539	Loop	10-40 T20	15	10	1	200	-10	0
49(b)	10/24/78	1532	Loop	10-40 T20	15	10	1	200	-10	0
50	10/24/78	1550	Loop	10-40 T20	13	10	1	200	-10	0
51	10/24/78	1629	Loop	10-40 T10	10	10	1	500	-10	0
52	10/24/78	1634	Loop	10-40 T10	15	10	1	200	-10	0

3.9.2 Noise Measurements

Simplistic assumptions based on measurements at other sites suggested that noise at the rectifier building might be some combination of impulsive train noise (at 400 impulses/second) and rectifier impulsive noise (synchronized with the PEPCO line frequency). However, this logical assumption was not valid. The measured noise at the rectifier building proved to be more complex than anticipated.

Figure 48 shows impulsive noise at the rectifier building over the 3 to 13 kHz band of frequencies. Two primary sets of slanting lines were found at periods of 20 ms (50 impulses/second). The pulses were separated by a fixed time of about 6.5 ms from 16.8 down to 13 seconds on the time axis. At this time the spacing between pulses gradually increased to about 12 ms at 10 seconds on the time axis where both pulses abruptly turned off. At 8 seconds the two pulses returned, along with additional low level impulse structure just barely above the threshold level used for the view.

Two additional views of impulsive noise at the rectifier building are shown in Figure 49 for the 10 to 20 kHz frequencies. In the upper view impulsive noise over the 10 to 13 kHz band of frequencies was similar to that found in the overlapping frequency range of Figure 48. From 14 to 20 kHz additional impulse structure was found at the 20 ms period. This additional impulse structure did not turn off at the off time of the lower frequency impulse components at 10 to 8 seconds on the time axis.

In the lower view of Figure 49 another example of impulse noise over the 10 to 20 kHz frequency range is shown. The display threshold was lowered and the complex multiple impulse structure was found over the entire band of frequencies. In additon an impulse sequence varied in time separation from the multiple impulse structure with a constant period of 20 ms (50 impulses/second).

In Figure 50 another example of rectifier building-associated impulse noise over the 8 to 18 kHz range is shown. Three closely spaced impulses were found, but two of these impulses shifted their time base at 10 seconds on the time axis. The two pulses then merged into a single impulse and display resolution was inadequate to resolve the two components from about 9 seconds down to 0 seconds on the time axis.

In Figure 51 the scan time of the receiver was changed from the 200 ms/scan time of the previous views to 500 ms/scan. This lengthened the observation time of the view to 34.8 seconds at the expense of reduced time resolution along the frequency axis. The variable properties of the impulse spacing can be seen where impulse timing patterns changed significantly several times during the 34.8 second time of the view.

In Figure 52 the scan time was returned to the 200 ms/scan value. At the top of the view (near 16.8 seconds on the time axis) a single well defined impulse can be seen to the left of the low level groups of impulses. This single impulse sequence changed its time base sufficiently to cross the low level impulses and appeared on the right side of the low level impulse groups. The time base shift was about 9 ms.

Available data indicates that the impulsive structure observed at the WMATA rectifier building was not synchronized with the 18 ms impulses found in Figures 45 and 46 (see Section 3.8.2). The rectifier building impulsive noise was apparently related to the 2.5 ms period of the train impulsive noise discussed in Section 3.8.2, but the rectifier building noise was four times the period of the train impulse period. The mechanism that produced this unusual relationship was not immediately apparent.

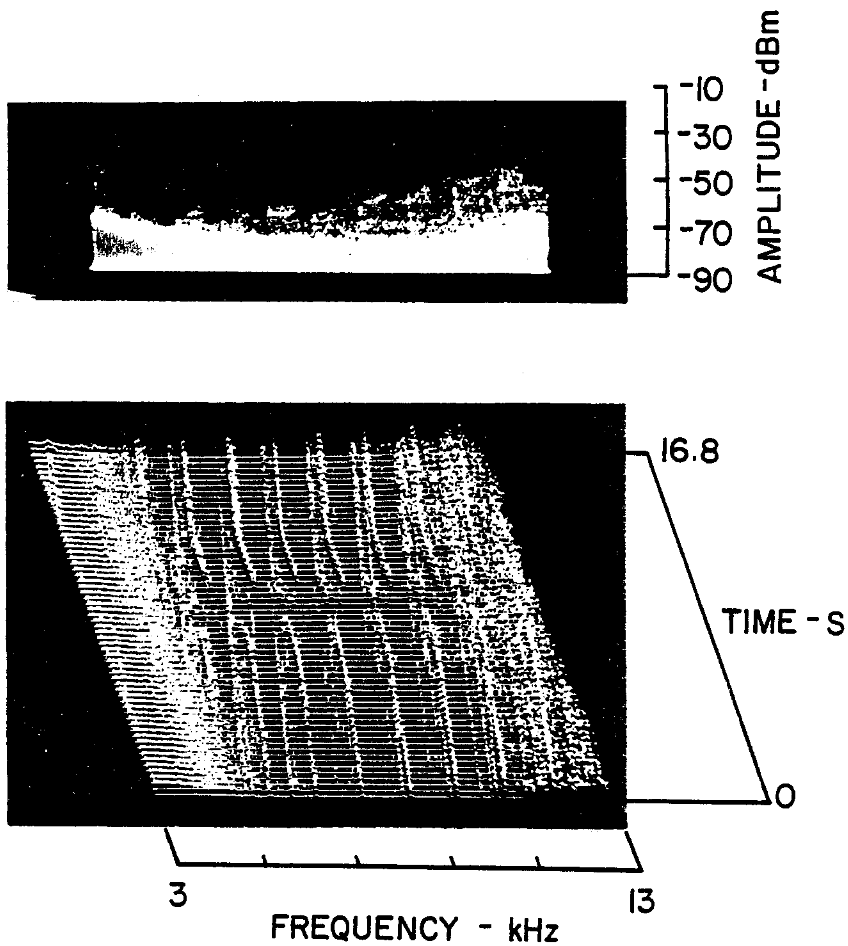


Figure 48 Rectifier Building Site, 10/24/78, 1528

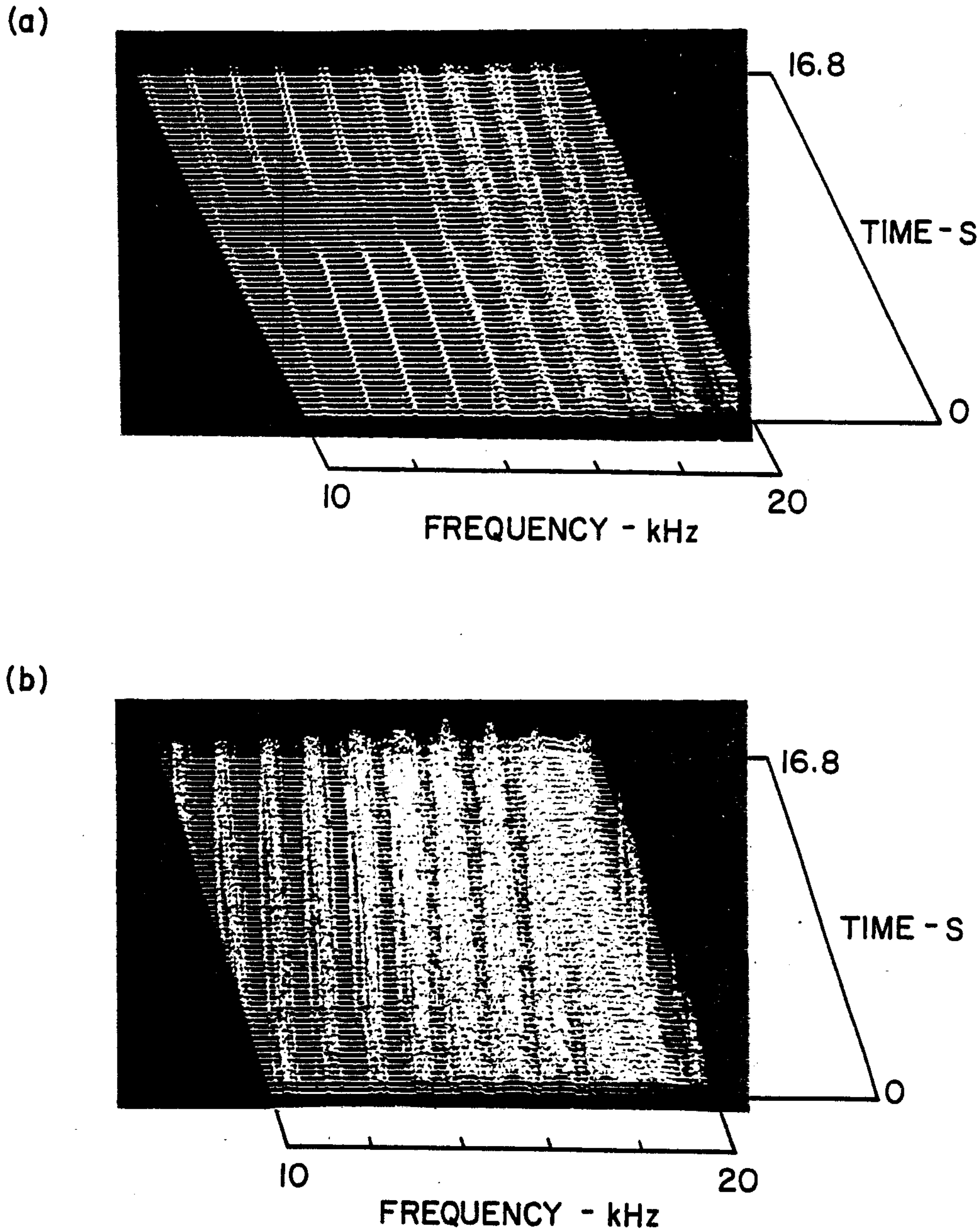


Figure 49 Rectifier Building Site, 10/24/78, 1539/1532

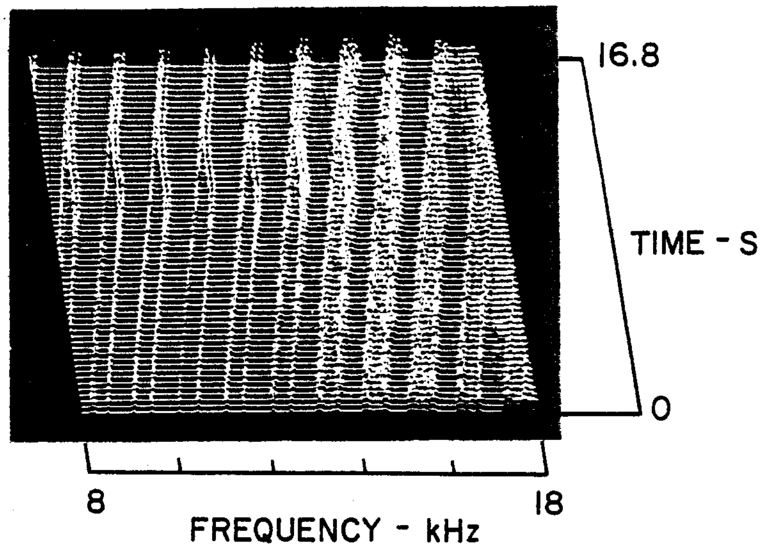


Figure 50 Rectifier Building Site, 10/24/78, 1550

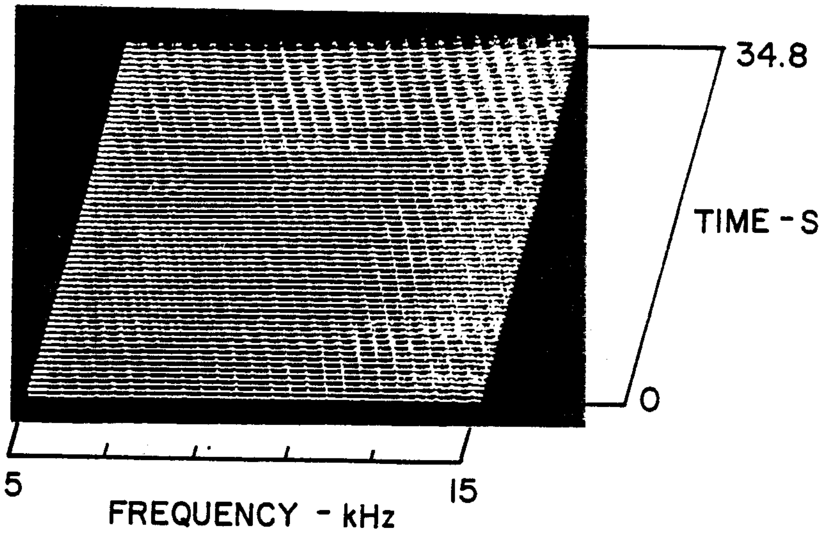


Figure 51   Rectifier Building Site, 10/24/78, 1629

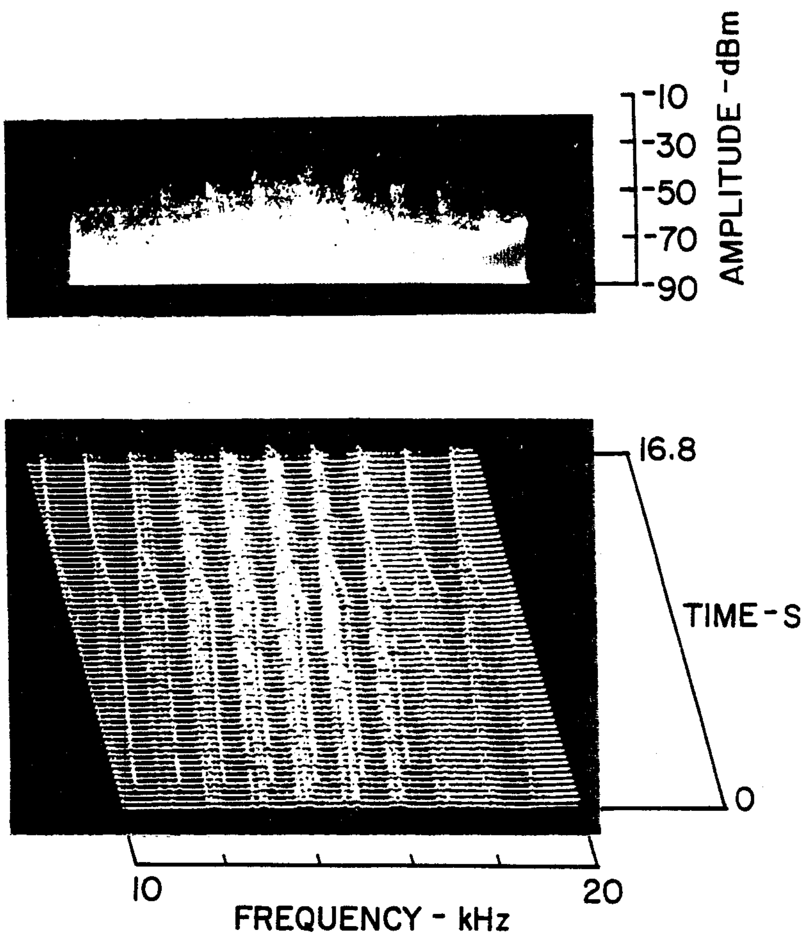


Figure 52 Rectifier Buidling Site, 10/24/78, 1634

Section 4

DISCUSSION

4.1 AMBIENT NOISE

Ambient or background impulsive noise conducted along and radiated from PEPCO distribution lines was significant. The primary background noise was impulsive and synchronous with the power line frequency. All available evidence suggested that the impulsive noise originated from high power synchronous switching devices employed by PEPCO customers for various industrial process controls. Impulses from these devices apparently propagated from each device, or source, backward through industrial plant wiring and plant feeder lines onto the PEPCO distribution lines. The distributed locations of industrial facilities containing impulse noise sources along the PEPCO distribution resulted in significant levels of background noise at all measurement sites. Noise properties varied somewhat from site to site as different noise sources were involved.

The major form or type of impulsive noise had a constant period related to single phase, three-phase, or two of the three phases of the PEPCO line. In addition a second type of noise was found where the impulse trigger point apparently varied along the line voltage waveform with time. This second type of noise gave distinct v- or z-shaped signals over narrow bands of frequencies.

Insufficient data were collected to fully analyze the propagation of background noise from its sources onto a PEPCO distribution line and along the distribution line, but considerable evidence existed which suggested that frequency sensitive parameters were involved in the generation, propagation, and radiation of the impulsive noise from the PEPCO distribution lines. For example, the variations in amplitude vs. frequency of the constant period impulsive noise and the band-limited features of the variable period impulsive noise indicate that frequency selective factors were involved. A full understanding of the frequency selective feature of the source-to-sink process of the impulsive noise was beyond the scope of the one-week field measurement effort.

Most individual sequences of impulses had well defined amplitude levels at any given frequency. However, multiple sequences of impulses were sometimes found with amplitude levels that varied from near random to a few distinct levels. While some data would have produced amplitude probability distributions that generally agreed with previous measurements [4,5], distinct level cases would have produced amplitude probability distributions with discontinuities. A full statistical analysis of the data would have produced an interesting variety of results; however, this was beyond the scope of the limited effort undertaken in the program.

Electrical noise associated with distribution line insulator and hardware leakage was expected to be a major source of backgound noise on the PEPCO distribution lines. However, the measurements did not confirm this expectation. No serious case of leakage noise was found at the sites measured.

The general properties of noise found to be conducted along and radiated from the PEPCO distribution lines was consistent with measurements of radio noise in other suburban and urban areas [6,7]. This general consistency suggests that the observed impulsive noise has become a nationwide factor.

4.2 WMATA RECTIFIER NOISE

Impulsive noise synchronous with the PEPCO line frequency and starting immediately upon application of WMATA train traction power was observed on PEPCO Feeder 14101. Low level noise was observed over the 4 to 12 kHz frequencies at the Riser Pole 14101 site. Modest noise levels were found at the P.G. Country Club site which was 4.6 kft from the riser pole. Low noise levels were found at the Landover Road site which was 9.8 kft from the riser pole. All impulsive noise signatures were similar in that groups of four or five impulses were spaced 8.3 ms apart. Pulses within each group were spaced about 1.7 ms apart or at about 36° intervals of phase delay along the line voltage waveshape.

Impulsive rectifier-associated noise measured at the Riser Pole 14101, P.G. Country Club, and Landover Road sites were all confined to the 3 to 10 kHz band of frequency. Instrumentation limitations prevented the convenient examination of rectifier noise levels below 3 kHz. Impulsive noise associated with train operation and the WMATA rectifier was not observed above 10 kHz. Noise amplitude increased as frequency decreased.

Impulsive noise associated with rectifier operation decreased in level as nearby capacitors were switched in. The large 12 MVAR substation capacitor bank, when switching, reduced noise levels considerably.

The low noise level measured at Riser Pole 14101 site, the higher noise levels measured at the P.G. Country Club site, and the low level noise measured at the Landover Road site imply that standing waves were present on the distribution line. The measured results suggested that a modest current maximum in noise existed at or near the P.G. Country Club site. This current maximum could have been defined by additional measurements at other locations along Feeder 14101, but sufficient time was not available to acquire such data during the brief one-week measurement period allocated for the task.

Impulse noise associated with the WMATA rectifier and train operation was not observed at the Riser Pole 14111 site or at the Greenleaf Avenue site on Feeder 14111. Riser Pole 14111 measurements were made before optimum instrumentation operating parameters had been established. Thus, Riser Pole 14111 site measurements cannot be considered conclusive. However, the lack of impulsive noise associated with the rectifier at the Greenleaf Avenue site was established. The Greenleaf Avenue site was 8 kft from Riser Pole 14111, which was less than the distance involved in the positive measurement of noise at Landover Road on Feeder 14101. This suggested that the electrical characteristics of the two feeders were somewhat different.

4.3 TRACTION MOTOR CONTROL NOISE

Impulsive noise associated with the train traction motor control was identified emanating from the WMATA tracks. The traction motor control impulse rate was 400 impulses/second (a period of 2.5 ms). While the impulses were prominent along the tracks, the impulses were not propagated back through the WMATA rectifer and onto the PECPO feeders.

A submultiple of the train traction motor impulse rate was identified at the rectifier site (see Section 3.9). The relationship between the 400 impulses/second rate from the train propulsion control and the 50 impulses/second rate found at the rectifier building site was not understood. Also, the reason for the small change in period of some of the impulses found at the rectifier building (Figures 48 through 52) has not been identified at this time.

4.4 IMPLICATIONS TO POWER CARRIER COMMUNICATIONS

Most power carrier communications systems are employed on transmission lines. The power carrier signals found in Sections 3.3.2 and 3.8.2 emanated from nearby utility transmission lines, and they were not carefully examined during this measurement effort. The noise levels described in this report were associated with utility distribution lines, and the measured noise cannot be applied to conventional power carrier communications systems operating on transmission lines.

A few operational power carrier communications systems and a number of experimental systems are now operating on utility distribution lines. These systems are employed for various control and telemetry purposes including functions such as switching, load control, status reporting, meter reading, and similar operations. Large expansions in these systems are currently being considered to reduce the cost of day-to-day operation of utilities. These expansions will be implemented to meet communications requirements as soon as communications system costs and performance reach reasonable levels.

Power carrier communications systems operate at the 5 to 500 kHz frequencies explored in these measurements. The impulsive noise levels measured at the various sites are the noise levels which will limit the performance of power carrier communications systems. A review of the available literature on noise levels limiting the performance of power carrier communications employed on distribution lines did not reveal significant or comparable data except for similar measurements in other cities [3,4].

The measurements suggest that significant levels of impulsive noise synchronous with the power line frequency will be experienced on many distribution lines in urban and suburban areas. Furthermore, the noise will vary (1) as sources are turned on and off, (2) with time of day, (3) as power factor correction capacitors are switched, (4) from distribution line to distribution line, (5) along a given distribution line, and (6) perhaps with other unknown factors. The measurements imply that attenuation/mile values of current or voltage often used in system design may not be realistic for field practice, and unusually low or unusually high values of attenuation/mile may be obtained for similar lines. The data suggest that standing waves exist along the distribution lines which must be considered in systems design and the standing wave patterns can be changed by discrete power line components such as capacitors and loads. Furthermore, the urban and suburban areas where carrier communications systems are most urgently needed are the areas with the highest population of impulsive noise sources.

These factors suggest that widespread use of power carrier communications on distribution lines will not be successfully implemented until noise control procedures are implemented, systems highly immune to a complex variety of impulsive noise conditions are developed, and systems capable of adjusting to complex impedance changes are devised. Consistent performance from installation to installation requires that both noise levels and propagation along the distribution line be better understood.

4.5 TERMINOLOGY

The term "impulsive noise" has been used throughout this report to describe the sequences of brief impulses that were found to be the predominant type of noise emanating from PEPCO distribution lines. The impulses can be physically related to switching transients created by devices in modern industrial process controls. These impulses were usually synchronized to the 1Ø or 3Ø power line waveforms because of the operation of the source devices.

The repetitive sequences of pulses, usually of constant period, can be analyzed for spectral detail by conventional Fourier transform analyses. The fine grain spectral structure can also be measured with spectrum analyzers based upon Fast Fourier Transform (FFT) techniques. Such analyses or measurements would show that harmonic spectral components of the power line frequency were present throughout the frequency range covered in this report. Cummins [3] has examined the fine scale spectral structure of power line noise by translating a small 4 kHz wide band of frequencies near 20 MHz downward to 0 to 4 kHz. The translation process was accomplished with a stable high frequency receiver operating in a linear mode. The 0 to 4 kHz translated band of frequencies was then examined with an FFT instrument. Distinct harmonic structure was identified with 60 and 120 Hz components.

The high frequency harmonic structure can be considered as an extension of the lower frequency and conventional power line harmonics.

In many respects these signals can also be called power line harmonics, or perhaps more properly as harmonics of the power line frequency.

The term "power line harmonics" seems to be somewhat misleading for the observed noise. The 3 to 300 kHz impulsive energy described in this report did not originate from utility power generation and transmission components. The harmonics originated from customer-related sources which fed impulsive energy back into PEPCO lines. The PEPCO distribution lines carried these impulses along with 60 Hz electrical power. The term "impulsive noise" was used to provide a means to distinguish between the energy generated by modern power control devices used by utility customers and the conventional power line harmonics which historically have been related to waveshape distortion from power generation and distribution systems.

The type of spectrum analyzer used in the measurements described in this report was not capable of resolving the 60 and 120 Hz spaced spectral lines at these higher frequencies. The scanning spectrum analyzer employed did provide the magnitude of these components vs. frequency. Thus, no significant data was lost, and significant advantages were obtained with the ability to scan across large blocks of frequencies, tune to any desired center frequency, and examine time domain structure.

Section 5

CONCLUSIONS

The exploratory measurements of electrical noise conducted along and emanating from PEPCO distribution lines was successfully concluded. The primary properties of background noise and WMATA rectifier-generated noise were defined. However, the measurements also raised significant questions concerning the electrical characteristics of the path from the noise source to the measurement location.

Most noise (background- and rectifier-generated) was impulsive and synchronous with the utility line frequency. The primary source of most background noise was believed to be high power switching devices employed by PEPCO customers for industrial process controls. Impulses from these devices propagated back through industrial facility wiring and onto PEPCO distribution lines.

The WMATA rectifier-generated noise was found only below 10 kHz. Higher frequency components were not detected at any measurement location. Noise level increased as frequency decreased. Instrumentation limitations prevented accurate measurements below about 3 kHz where maximum amplitude was found. Maximum WMATA rectifier noise was only a few dB above the background noise (P.G. Country Club site), and at most sites it was lower in amplitude than background noise. Thus, WMATA recifier noise did not appear to be a significant factor affecting other systems such as power carrier communications on distribution lines or other communication systems.

The non-frequency flat properties of the impulsive noise suggested that significant frequency selective efforts were involved in the source-to-measurement path. An improved understanding of the electrical properties of the source mechanisms, propagation path, and radiation from the PEPCO lines is required to fully explain all aspects of the noise observed. The one-week measurement period was far too short to allow time to define all electrical properties of the complex array of components involved over the large frequency range examined.

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Technical Report
NW9705A

June 1997

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM SURVEY, NSGA NORTHWEST

Prepared for:

Commander
NSGA Northwest
and
Commander
Naval Security Group, N-44
Fort George G. Meade. MD

Prepared by:
NW9705 SNEP Team

PREFACE

A Signal-to-Noise-Enhancement (SNEP) Team visited NSGA Northwest from 28 April through 9 May 1997. The primary purposes of the visit were to (1) identify and document site parameters that adversely affect the reception of radio signals, if any exist, and (2) continue the effort to reduce the adverse effects of radio interference from power lines on signal reception.

A "Quick-Look" type of report was provided to the Commander, NSGA Northwest, and to the Commander, Naval Security Group N-44, at the completion of the visit. This Technical Report replaces the Quick-Look report. It is a more comprehensive reporting of the findings of the NW9705 SNEP team visit, and additional documentation of the data obtained is provided along with an improved summary of the findings.

The noise floor data provided in the Quick-Look report was somewhat different than that from other similarily equipped sites. Since the values obtained during the visit could not be explained, a follow-up visit was made by two team members during the week of June 23, 1997. The noise floor data was again measured, resulting in new values. The new values are used in this report.

A list of the NW9705 SNEP team members is provided in Appendix A along with the names of site personnel who directly aided the team in the completion of its work. The team is grateful for the support provided by the Commander, NSGA Northwest, Captain Peyronel, and her entire staff. We were promptly provided access to all radio systems, power systems, and other parts of the facility as required for the completion of our work.

The casual reader might wish to first review the material in Section 1 (Introduction) and then go directly to Section 4 (Discussion) and Section 5 (Findings and Conclusions). The technical support for these sections is provided in Section 2 (Implementation of Objectives) and Section 3 (Signal Reception Analysis). Readers interested in the technical details of the data and findings can examine Section 2 and 3.

CONTENTS

PREFACE i
CONTENTS ii
LIST OF FIGURES iv
LIST OF TABLES vi

1. INTRODUCTION AND OBJECTIVES 1

2. IMPLEMENTATION OF OBJECTIVES
- 2.1 Pre-Visit Preparation 3
- 2.2 Site Factors 5
  - 2.2.1 RFD Gain/Loss 5
  - 2.2.2 RFD Noise Floor 7
  - 2.2.3 Operating Noise Floor 11
- 2.3 Power-Line Noise 17
- 2.4 Motor-Controller Interference 24
- 2.5 UPS Interference 37
- 2.6 NATO SATCOM Generator Interference 45
- 2.7 Fluorescent Lights 52
- 2.8 Electric Fence Interference 60
- 2.9 Comparison of Combined Omni and Conical Monopole Antennas 62
- 2.10 General Signal Reception 65

3. SIGNAL RECEPTION ANALYSIS 70
- 3.1 Approach 70
- 3.2 Reception of Source 1 72
- 3.3 Reception of Source 1A 79
- 3.4 Reception of Source 2 87
- 3.5 Reception of Source 2A 94

4. DISCUSSION 101
- 4.1 General Review 101
- 4.2 Power-Line Noise 102
- 4.3 Other Sources of Radio Interference 102
- 4.4 Site Parameters 104

5. FINDINGS AND CONCLUSIONS 105

APPENDICES

A PERSONNEL

B REVIEW OF SOURCES OF POWER-LINE NOISE IDENTIFIED ON PRIOR VISITS

C NEW SOURCES OF POWER-LINE NOISE

D IONOSPHERIC ACTIVITY REPORTS

LIST OF FIGURES

2.2-1 Primary and Secondary Coverage Areas for the Northwest Site 4

2.2.1-1 Plot of Noise Floor Values 6

2.2.2-1 Noise Floor for Terminated Beam A156 8

2.2.3-1 Graphic Presentation of the Operating Noise Floor for Beam 084 14

2.2.3-2 Graphic Presentation of the Operating Noise Floor for Beam 156 15

2.2.3-3 Graphic Presentation of the Operating Noise Floor for Beam 288 15

2.3-1 Map of Sources of Power-Line Interference 19

2.3-2 Fine-Scale Temporal Structure of a Single Source of Power-Line Noise 20

2.3-3 Fine-Scale Temporal Structure of Three Sources of Power-Line Noise 21

2.3-4 Combination of Noise from a Power Line and a Power-Control Device 23

2.4-1 Interference from Variable-Speed Motor Controller for Air Handler 25

2.4-2 Coarse-Scale Spectral and Temporal Structure of Interference Radiated from the Motor Controller 27

2.4-3 Fine Spectral and Temporal Structure of Interference Radiated from the Motor Controller 28

2.4-4 Common-Mode EMI Current Injected back onto the Phase Conductors in the Power Panel 29

2.4-5 EMI Current Injected into the Ground Conductor in the Power Panel 30

2.4-6 EMI Current on the 208-V, 3-Phase Power Conduit for the Motor Controller 32

2.4-7 EMI Current on the 120-V, Single-Phase Power Conduit for the Motor Controller . 33

2.4-8 EMI Current on the Conduit from the Motor Controller to the Motor 34

2.4-9 EMI Current on the Shield of the Power Cable to the Coyote Van 36

2.5-1 Impulsive Interference from the Site's UPS on Beam LB-060 38

2.5-2 Impulsive Interference from an UPS in the GE-Americom SATCOM Shelter 39

2.5-3 Radiation from the GE-Americom SATCOM Shelter 41

2.5-4 EMI Current on UPS Input Power Conduit 42

2.5-5 EMI Current on Shield of TWT Power Cable 43

2.6-1 EMI Current of the Field Excitation Cable 46

2.6-2 Fine-Scale Temporal Structure of EMI Current on the Field Excitation Cable 47

2.6-3 EMI Current on the Generator Output Conductors 48
2.6-4 EMI Current on Generator Ground Wire 50
2.6-5 EMI Current on Generator Oil Pump Line 51
2.7-1 EMI Current on Conduit Feeding Fluorescent Lights with Magnetic Ballasts 53
2.7-2 EMI Current on the Support Wire for a Fluorescent Light Fixture 55
2.7-3 Time-Varying EMI Current on Conduit Feeding Fluorescent Lights, Example 1 .. 56
2.7-4 Time-Varying EMI Current on Conduit Feeding Fluorescent Lights, Example 2 .. 57
2.7-5 Transient Current on the Conduit Feeding Fluorescent Light Fixture 58
2.7-6 Low-Frequency EMI Current on Conduit Feeding Fluorescent Light Fixture 59
2.8-1 Interference from an Electric Fence 61
2.10-1 Beacon Reception, Example 1 66
2.10-2 Beacon Reception, Example 2 68
2.10-3 Beacon Reception, Example 3 69
3.2-1 Map Showing Location for Source 1 73
3.2-2 Signals from Source 1 Exceeding Noise Floor of Primary Multicouplers 75
3.2-3 Signals from Source 1 Exceeding the Noise Floor of the Multicouplers and a 12-dB Detection Margin 77
3.2-4 Signals from Source 1 Exceeding the Detection Margin, RFD Loss, and RFD Noise 78
3.2-5 Signals from Source 1 Exceeding the Detection Margin, RFD Loss, and Operating Noise Floor 78
3.3-1 Map Showing Location of Source 1A 80
3.3-2 Signals from Source 1A Exceeding Noise Floor of Primary Multicouplers 82
3.3-3 Signals from Source 1A Exceeding the Noise Floor of the Multicouplers and a 12-dB Detection Margin 84
3.3-4 Signals from Source 1A Exceeding the Detection Margin, RFD Loss, and RFD Noise85
3.3-5 Signals from Source 1A Exceeding Detection Margin, RFD Loss, and Man-made Radio Noise 86
3.4-1 Map Showing the Location of Source 2 88
3.4-2 Signals from Source 2 Exceeding the Noise Floor of the Primary Multicouplers ... 90
3.4-3 Signals from Source 2 Exceeding a 12-dB Threshold 92
3.4-4 Signals from Source 2 Exceeding Detection Threshold, RFD Loss, and RFD Noise 93

3.5-1 Signals from Source 2A Exceeding the Noise Floor of the Primary Multicouplers . 96

3.5-2 Signals from Source 2A Exceeding a 12-dB Threshold 98

3.5-3 Signals from Source 2A Exceeding 12-dB Threshold, RFD Loss, and RFD Noise . 99

3.5-4 Signals from Source 2A Exceeding Detection Threshold, RFD Loss, and Man-Made Noise 100

LIST OF TABLES

2.2.1-1 RFD Signal Loss 6

2.2.3-1 Operating Noise Levels for Beam 084 11

2.2.3-2 Operating Noise Levels for Beam 156 12

2.2.3-3 Operating Noise Levels for Beam 252 13

2.9-1 Comparison of Signal Reception by the CO and CM Antennas, High Band 63

2.9-2 Comparison of Signal Reception by the CO and CM Antennas, Low Band 64

3-1 Signal Sources 70

3.2-1 PROPHET Output for Source 1 74

3.3-1 PROPHET Output for Source 1A 81

3.4-1 PROPHET Output for Source 2 89

3.5-1 PROPHET Output for Source 2A 95

1. INTRODUCTION AND OBJECTIVES

A Signal-to-Noise Enhancement Program (SNEP) team visited NSGA Northwest from 28 April through 9 May 1997. The major purposes of the visit were to:

- Review the status of each source of power-line noise identified during past visits.
- Complete a survey of external and internal noise and interference in each beam.
- Identify new sources of power-line noise, including motor-controller sources, to the extent feasible in the time available.
- Examine the EMI aspects of fluorescent lights with electronic ballasts, uninterruptible power supplies (UPS), and other potential sources of internal noise and interference.
- Complete a gain/loss survey of the radio-frequency distribution system.
- Compare the ability of the combined omni and the conical monopole antennas to receive selected signals.
- Assess the present impact of site factors and power-line noise on the ability of the site to receive selected sources of radio signals.

This Technical Report provides a comprehensive summary of the team's findings. It is identified by the designation of NW9705A, and it supplements the Quick-Look Report provided by the team prior to the end of the survey. All data files and other files carry the designation NW9705.

The NW9705 SNEP team members are listed in Appendix A along with site personnel who aided the team during the visit.

Appendix B summarizes the available data about several sources of power-line noise identified by prior teams. The current status of each distribution-line related source was determined by visiting and making noise measurements at each source.

While several new sources of power-line noise were found during the NW9705 survey, the duration of the visit was too short to complete a full-scale survey of all new sources. Appendix C provides a list of those new sources of power-line noise which were located.

The ability of the site to receive signals from several selected sources was evaluated. This evaluation was based on measured site parameters and on ionospheric propagation path conditions at the time of the survey. The reception of signals from distant sources depends on the state of the radio-signal reflecting layers of the earth's ionosphere, and this varies from season to season and with solar activity. The near real-time state of the ionosphere, as determined from measurements of solar activity, was determined and documented each day during the visit. Appendix D provides examples of the solar-activity documentation. This information was also used as an input for the propagation predictions used in the analysis of signal reception.

2. IMPLEMENTATION OF OBJECTIVES

2.1 PRE-VISIT PREPARATION

A number of pre-visit work tasks must be completed prior to arrival of a SNEP team at a site. These tasks include the preparation of a comprehensive test plan, the selection of instrumentation, tools, and supplies, the testing of instrumentation, the packing and shipping of instrumentation, tools, and supplies, obtaining maps of the area around the site, preparing a site coverage map, selecting test-signal sources, and completing initial propagation analyses for the paths from each test-signal source to the site. This pre-trip preparation is a necessary aspect of the evaluation of the impact of site factors on the reception of test and other signals.

In addition to the above, all available documents about factors which might affect the reception of signals at the Northwest site were identified and copies of pertinent documents were provided to each team member for review prior to arrival at the site. Data in these documents that might aid team members during the new survey was identified and highlighted.

Knowledge of the effective coverage area of the Northwest site is necessary to understand its inherent signal-reception capabilities. Figure 2.1-1 is a great-circle map showing the primary- and secondary-coverage areas of the Northwest CDAA site. The primary coverage area is defined as the area from the station out to the maximum distance of a one-hop ionospheric reflection. The secondary-coverage area is defined as that portion of the globe between the one-hop reflection limit and the two-hop reflection limit. The probability of reception of a radio station in the secondary area will be lower than an identical station in the primary-coverage area, and its received signal level will be about 15-dB lower than a similar station located in the primary-coverage area. The probability of reception of stations located beyond the two-hop limit is too low for reliable signal-intercept purposes, although stations will occasionally be heard from more distant locations.

The monthly average diurnal changes in maximum and minimum frequency limits and signal strength from stations located in the primary and secondary coverage areas can be predicted with standard propagation prediction programs. Version 4.3.1 of the PROPHET prediction program is used later in this document to understand the reception of selected sources of signals.

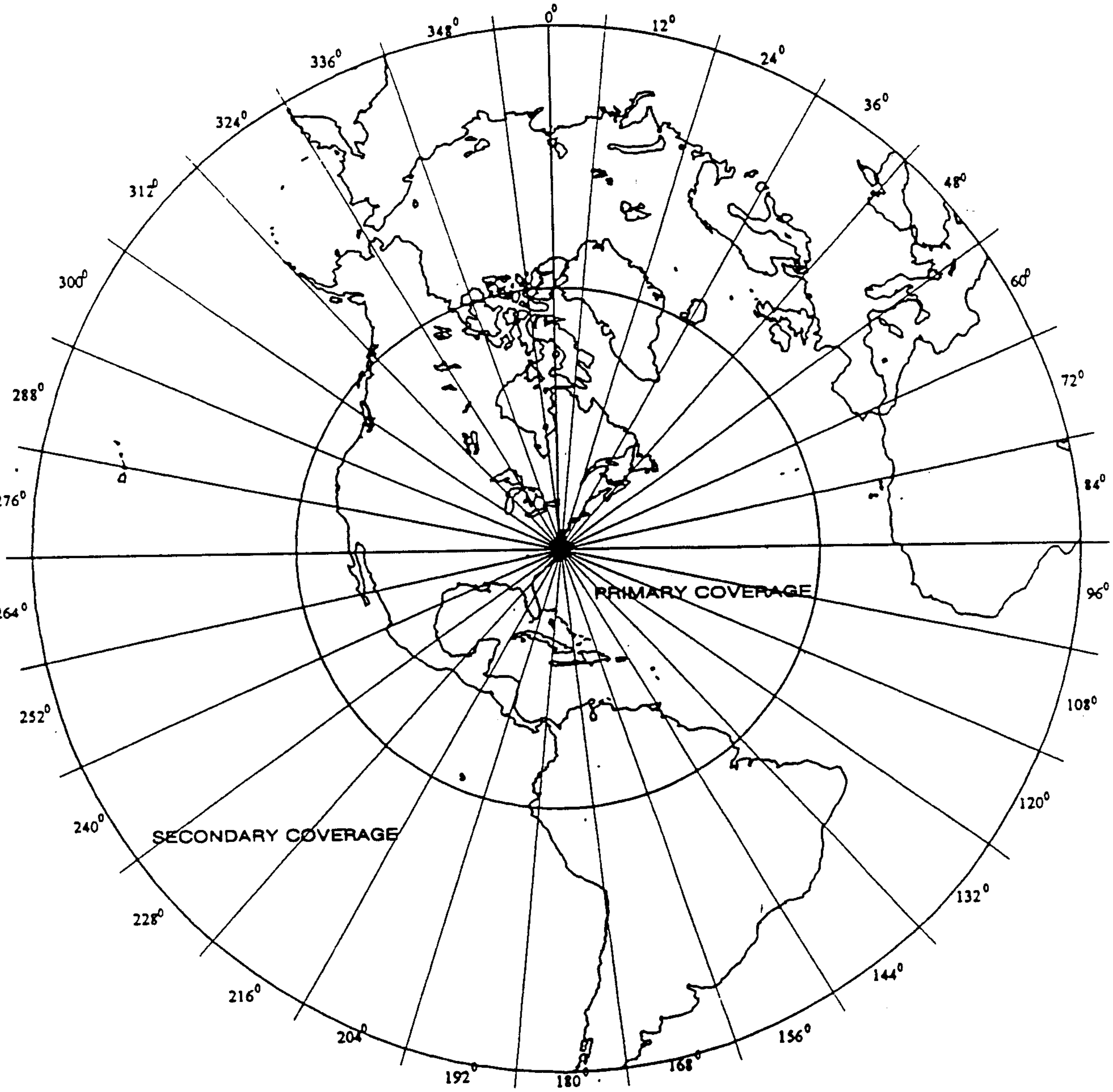

Figure 2.1-1

Primary and Secondary Coverage Areas for the Northwest Site.